



(22) Date de dépôt/Filing Date: 2007/01/29

(41) Mise à la disp. pub./Open to Public Insp.: 2008/07/29

(45) Date de délivrance/Issue Date: 2013/10/22

(51) Cl.Int./Int.Cl. *F04B 49/06* (2006.01),  
*F04B 47/00* (2006.01)

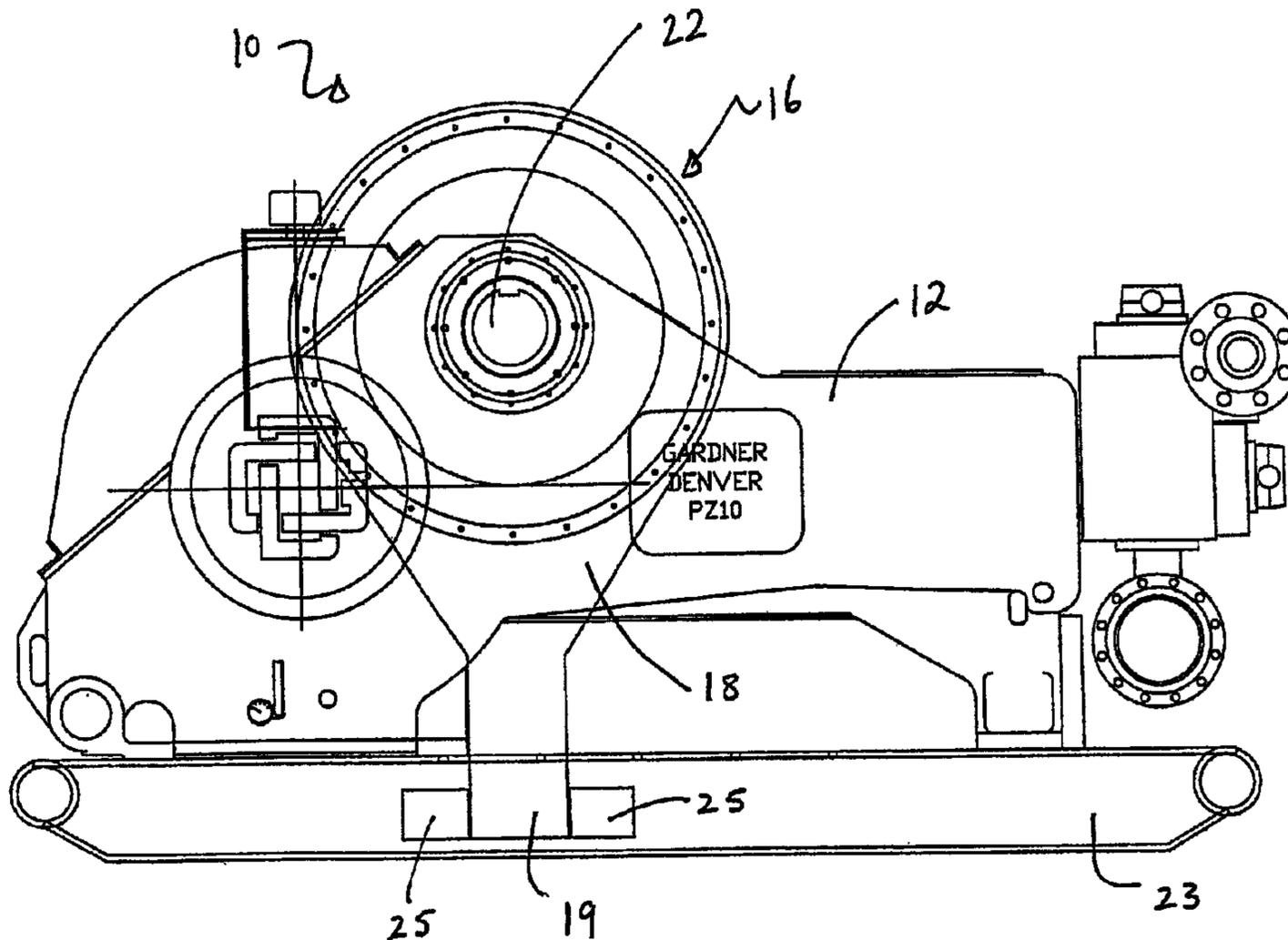
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(54) Titre : DISPOSITIF D'ENTRAINEMENT DE POMPE HYDRAULIQUE

(54) Title: FLUID PUMP DRIVE



(57) Abrégé/Abstract:

An apparatus and method for powering a fluid pump used in connection with drilling operations. The apparatus has an electric motor with a rotor that connects directly to the drive means of the fluid pump in a direct drive configuration.



**ABSTRACT**

An apparatus and method for powering a fluid pump used in connection with drilling operations. The apparatus has an electric motor with a rotor that connects directly to the drive means of the  
5 fluid pump in a direct drive configuration.

## FLUID PUMP DRIVE

### FIELD OF THE INVENTION

The present invention relates to an apparatus and method for powering a fluid pump, and  
5 more particularly to an apparatus and method for powering the drive means of a fluid pump.

### BACKGROUND OF THE INVENTION

During drilling operations a number of different types of pumps are used to move and  
circulate fluids. These pumps all generally operate in the same manner being two or three-  
cylinder piston pumps whose replaceable pistons travel in replaceable liners that are driven by a  
10 crank shaft. In some pumps the crank shaft is itself driven, via gears, by a drive shaft (also  
sometimes called a pinion shaft). The crank shaft, or the drive shaft as the case may be, is  
actuated by an engine or a motor. Examples of such pumps used in connection with drilling  
operations include water pumps, slurry pumps, nitrogen pumps and cement pumps. Another  
example of such a pump is a mud pump. During drilling operations for oil and gas, a mixture of  
15 clays and chemicals and water, is pumped down the drill pipe to lubricate and cool the drilling  
bit and to flush out the cuttings and to strengthen the sides of the hole. This mixture is  
commonly referred to as drilling mud. A large reciprocating pump known as a mud pump is  
used to circulate the drilling mud.

As shown in Figure 1, conventional fluid pumps such as the mud pump have a power  
20 source configured in an indirect drive manner with the power source positioned adjacent to the  
mud pump. The power source is frequently positioned above or behind the pump. The power  
source is connected to one or more gearboxes in a variety of ways including the use of shafts,  
couplings, belts, pulleys, chains, transmissions or clutches. The gearbox in turn is connected to  
the drive shaft or crank shaft of the fluid pump using belts, chain drives or other conventional  
25 drive mechanisms. Such indirect drive fluid pump systems have a number of disadvantages.  
First, indirect drive power systems occupy a considerable amount of space in an already crowded

environment. Further, conventional indirect drive systems are prone to alignment problems and the gearbox of such conventional systems require frequent maintenance and lubrication. Also, during the transmission of power through an indirect drive system, there are material energy losses and a resulting inefficiency associated therewith.

## 5 SUMMARY OF THE INVENTION

The present invention is directed to apparatus and method of powering the drive means of a fluid pump.

Accordingly, in one aspect of the invention, the invention comprises an apparatus for powering the drive means of a fluid pump, the apparatus comprising:

- 10           (a)     an electric motor having a stator and a rotor, the rotor being releasably attached to the drive means of the fluid pump such that the drive means is directly driven by the rotor;
- (b)     restraint means attached to electric motor to restrain rotational movement of the stator; and
- 15           (c)     means for connecting the electric motor to a source of electricity.

In one embodiment the fluid pump is a mud pump. In another embodiment, the rotor is a hollow rotor, and the drive means of the fluid pump is a drive shaft, and the hollow rotor is adapted to slide onto and attach to the drive shaft. In one embodiment, the rotor is a hollow rotor, and the drive means of the fluid pump is a crank shaft, and the hollow rotor is adapted to slide onto and  
20 attach to the crank shaft. In one embodiment, the electric motor is supported by the drive means of the fluid pump.

In one embodiment, the restraint means comprises a torque arm being attached at one end to the electric motor. In another embodiment, there is means for restraining the distal end of the torque arm. In embodiments of the present invention, the motor may be an AC induction electric motor,  
25 a DC traction electric motor, DC switch reluctant electric motor or a permanent magnet electric

motor. In one embodiment, the rotor is hollow, the interior of the hollow rotor is tapered, and the rotor is attached to the drive means using a taper lock.

In another aspect of the present invention, the invention comprises an apparatus for powering the drive shaft of a fluid pump, the apparatus comprising:

- 5           (a)    an electric motor having a stator and a hollow rotor, the interior of the hollow rotor being tapered, the rotor being releasably attached to the drive shaft of the fluid pump by a taper lock and a key, the key inserting into a complimentary recess on the drive shaft, such that the drive means is directly driven by the rotor;
- 10           (b)    restraint means attached to electric motor to restrain rotational movement of the stator; and
- (c)    means for connecting the electric motor to a source of electricity.

In another aspect of the invention, the invention comprises an apparatus for powering a mud pump, the mud pump having a base and a drive shaft, the drive shaft having a longitudinal axis, the apparatus comprising:

- 15           (a)    an electric motor mounted on the drive shaft, the electric motor comprising:
- (i)    a stator;
- (ii)   a hollow rotor having a longitudinal axis, the hollow rotor being adapted to slide onto and engage the drive shaft such that the longitudinal axis of the hollow rotor and the longitudinal axis of the drive shaft are aligned, whereby the rotor directly drives the drive shaft; and
- 20           (iii)   a torque arm attached to the stator, the torque arm extending out and away from the electric motor in a plane that is substantially perpendicular to the longitudinal axis of the rotor;

- (b) at least two restraining members attached to the base of the mud pump positioned on either side of the torque arm proximate to the end of the torque arm furthest from the electric motor.

In another aspect of the present invention, the invention comprises a method of powering the drive means of a fluid pump using an electric motor having a rotor and a stator, the method comprising the steps of:

- (a) releasably attaching the rotor of the electric motor to the drive means such that the rotor directly drives the drive means of the fluid pump;
- (b) supplying electrical power to the electric motor; and
- 10 (c) restraining rotational movement of the stator.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by way of an exemplary embodiment with reference to the accompanying simplified, diagrammatic, not-to-scale drawings. In the drawings:

5 Figure 1 is a diagrammatic top view of a mud pump and conventional indirect drive power system (prior art).

Figure 2 is a diagrammatic top view of a mud pump and one embodiment of the present invention.

Figure 3 is a diagrammatic side view of a mud pump.

10 Figure 4 is a diagrammatic side view of the apparatus mounted on a mud pump in one embodiment of the present invention.

Figure 5 is a diagrammatic depiction of an electric motor and torque arm of one embodiment of the present invention.

15 Figure 6 is a diagrammatic side view of one embodiment of the electric motor of the present invention

Figure 7 is a diagrammatic side view of one embodiment of the torque arm of the present invention.

Figure 8 is a diagrammatic depiction of a front view of the torque arm of one embodiment of the present invention.

20 Figure 9 is a diagrammatic depiction of a front view of the electric motor of one embodiment of the present invention.

Figure 10 is a front view of an electric motor mounted and a torque arm in one embodiment of the present invention.

Figure 11 is a top view of an uncoupled electric motor and torque arm of one embodiment of the present invention.

Figure 12 is a top view of an electric motor mounted on a torque arm of one embodiment of the present invention.

5 Figure 13 comprises an exploded side view of a taper lock and key attachment system of one embodiment of the present invention.

Figure 14 comprises a side view of a taper lock mounted on a drive shaft of one embodiment of the present invention.

10 Figure 15 comprises a side view of an electric motor and torque arm mounted on a drive shaft with a taper lock of one embodiment of the present invention.

## **DETAILED DESCRIPTION OF THE INVENTION**

### **Scope**

15 When describing the present invention, all terms not defined herein have their common art-recognized meanings. To the extent that the following description is of a specific embodiment or a particular use of the invention, it is intended to be illustrative only, and not limiting of the claimed invention. The following description is intended to cover all alternatives, modifications and equivalents that are included in the spirit and scope of the invention, as defined in the appended claims.

### 20 **Definitions**

In this patent the following words are intended to have the following meaning:

"AC" shall mean alternating current.

25 "crank shaft" shall mean a driven shaft in a fluid pump that is used to drive the pistons of the fluid pump by means of one or more connecting rods.

"DC" shall mean direct current.

"directly driven" shall mean a configuration whereby a first component is directly attached to a second component whereby rotation of the first component results in direct drive rotation of the second component.

5 "drive shaft" shall mean a driven shaft in a fluid pump used to drive the crank shaft of the fluid pump.

"fluid pump" shall mean any cylinder piston pump used in connection with, or in relation to drilling operations (including, without limitation, oil and gas drilling operations), the cylinder piston pump having a plurality of pistons that are driven by a drive means that is actuated by an  
10 engine or a motor.

"mud pump" shall mean a fluid pump used to circulate the drilling mud.

"rotor" shall mean the rotating part of an electric motor.

"stator" shall mean the stationary part of an electric motor.

### **Description**

15

The present invention is directed to an apparatus for powering the drive means of a fluid pump and to a method of powering a fluid pump. The drive means of a fluid pump can comprise a crank shaft that is rotated to reciprocate the pistons and connecting rods. Alternatively, the drive means may comprise a drive shaft connected to a crank shaft by any suitable gearing  
20 system. In this configuration, rotation of the drive shaft results in rotation of the crank shaft which in turn reciprocates the pistons. The present invention may be used with either configuration of drive means.

Use of the invention for powering a mud pump having a drive shaft connected to a crank shaft shall be described below and is shown in the Figures. However, the invention may be used  
25 with any fluid pump having just a crank shaft, or having a drive shaft connected to a crank shaft. Although the Figures depict a Gardner Denver™ mud pump, it will be understood the apparatus (10) can be used with any conventional mud pump including without limitation OEM™ pumps, National Oilwell™ pumps, Varco™ pumps and Emsco™ Pumps.

Mud pumps are used on drilling rigs to circulate drilling mud. The mud pump forces drilling mud down the drill string and into the borehole to lubricate and cool the drilling bit and to flush out the cuttings and to strengthen the sides of the hole. Mud pumps typically comprise a large two or three-cylinder reciprocating piston pump that is driven by a drive shaft connected to a crank shaft actuated by an engine or a motor. As shown in Figure 2, the drive shaft (22) is elongate having a longitudinal axis (B) that is perpendicular to the longitudinal axis of the mud pump (12) itself. Mud pumps are generally found in a pump house adjacent to a drilling rig. Figure 3 shows a diagrammatic side view of conventional mud pump produced by Gardner Denver™. The mud pump (12) is mounted on a base (23) to facilitate skid mounting and movement. The drive shaft (22) drives an internal crank shaft (not shown in the Figures) that in turn drives reciprocating pistons and connecting rods (not shown in the Figures) when rotated. The mud pump (12) has an intake for receiving drilling mud from a storage facility and has an outlet to deliver the drilling mud under pressure to the drill string.

The conventional manner of powering a mud pump (12) consists of the use of an engine or motor that has a shaft connected to a gearing system. The gearing system is in turn connected to the drive means of the mud pump by belts, chains or other means. It can be understood that in such a conventional system the engine or motor powers an intermediary component, namely the gearing system, which in turn powers the drive means of the mud pump. This configuration shall hereinafter be referred to as an "indirect drive system". In indirect drive systems, the engine or motor is usually either rear or top mounted about the mud pump (12). Figure 1 depicts a rear mounted indirect drive system (14) connected to both sides of the drive shaft (22) of a mud pump (12). More than one drive system may be employed as shown in Figure 1 when high levels of horsepower are required. Figure 2 shows a top view of a mud pump (12) with the apparatus (10) of the present invention mounted to it. As can be seen, the apparatus (10) occupies less space than an indirect drive system. The saved space is beneficial in the context of a crowded drilling environment. The smaller size also results in a decrease in weight which is particularly beneficial during the assembly, disassembly and movement of drilling rigs.

The apparatus (10) comprises an electric motor (16) having restraint means. As shown in the Figures, in one embodiment the restraint means may comprise an torque arm (18) that is attached to the electric motor and which extends outwards in a plane that is substantially perpendicular to

longitudinal axis of the rotor (A). In one embodiment the weight of the electric motor (16) is supported by the drive shaft (22), or the crank shaft as the case may be, and the purpose of the torque arm (18) is to restrain rotational movement of the stator during operation of the electric motor. As shown in the Figures, the torque arm (18) and motor (16) may have complimentary bolt-holes to facilitate mounting of the torque arm using nuts and locking bolts. However, any other suitable method of releasably mounting the motor (16) to the torque arm (18) as would be employed by one skilled in the art may be selected. Releasable attachment facilitates easy maintenance and removal of the electric motor (16) if required. Alternatively, the electric motor (16) may be produced such that the torque arm (18) forms an integral piece thereof. For example, the torque arm may also serve as an end plate of the motor.

The apparatus (10) also has means to restrain movement of the end of the torque arm distal from the electric motor (19). The means may comprise an attachment with the fluid pump itself and the end of the torque arm may be attached to mud pump (12) by bolts, welding or other suitable means. However, having regard to the fluctuating torque loads placed on the torque arm (18), it is preferred, but not essential, to implement a configuration that allows for a small degree of free play. In the embodiment shown in the Figures, the end of the torque arm (19) is inserted between two restraining members (25) mounted to the base of the mud pump (23). The restraining members may simply comprise stopper blocks welded to the mud pump (12). There is a small gap between the edges of the torque arm (18) and the stopper blocks. This allows minor amounts of movement but restrains rotation of the stator (21) and the motor (16) as a whole. The means for restraining the end of the torque arm (18) may also comprise a single stopper block that is notched to accommodate the end of the torque arm. In further embodiments, the means for restraining the torque arm can comprise a spring-loaded attachment or a stopper block, or blocks, constructed of an elastomeric polymer.

The torque arm (18) can be made from any suitable material, but it must be strong enough to withstand the torque forces placed on it by virtue of the rotating motor rotor (20) coupled to the drive shaft (22) during pumping operations. Iron alloys and steel alloys have been found to be suitable. As shown in the Figures, in one embodiment, the torque arm (18) may be shaped like a tennis racquet having a shaft (17) and a hollow upper portion (19) through which the drive shaft (22) of the mud pump (12) may project to attach to the rotor (20) of the electric motor (16).

However, such suggestion of shape is not intended to be limiting of the invention claimed herein, and any functional shape may be used. Although the Figures show the torque arm (18) extending down in a substantially vertical orientation, it can be understood that the torque arm (18) may extend in any direction and can releasably engage any suitable portion of the mud pump (12).

The electric motor (16) comprises a stator (21) and a rotor (20) that rotates inside the stator on a bearing system. Any suitable electric motor may be used, including without limitation, an AC induction motor, a DC traction motor, a DC switch reluctant motor or a permanent magnet motor. In one embodiment, because there is no gearing system being utilized, the electric motor selected must be able to generate sufficient torque for the intended application. The electric motor is connected to a source of electricity such as a generator using insulated cables, or any other suitable means commonly employed by those skilled in the art. There may preferably be an air gap between the rotor (20) and the stator (21). In one embodiment, a hollow bore electric motor is used which has a hollow rotor.

The electric motor may have an optional coolant system, if required (not shown in the Figures) for cooling the electric motor. The coolant system can be a liquid-cooled system or an air-cooled system, or both, depending on the needs of the electric motor. In one embodiment employing a liquid cooled system, coolant is held in a reservoir and is then pumped through filters to a coolant hose that supplies the stator (21). The coolant is circulated through the stator (21) through tubes drawing heat from the stator (21). The heated coolant is removed from the stator (21) using a return hose or tube, or a plurality of hoses, and is cooled using a cooling radiator or shell and tube cooler system. After being cooled, the coolant is returned to the reservoir. The system has a pump to circulate the coolant and has flow, and temperature controls and monitors. Dependant on the operation climate, the coolant may be a water/glycol mix, and may include a corrosion inhibitor.

In another embodiment, the stator (21) and rotor (20) can be air cooled by force blowing large volumes of air across these components. An inlet can be created using a plate at one side of the stator (not shown in the Figures) and an outlet may be created at the other end in a similar

manner. Air that has been filtered to remove debris and particles is passed across the stator (21) and rotor (20) using a fan from the inlet to the outlet, thereby cooling the motor.

As shown in Figures 5, 10 and 12, in one embodiment the electric motor (16) is attached directly to the drive shaft (22) so that the longitudinal axis of the rotor of the electric motor (A) and the longitudinal axis of the drive shaft (B) are aligned. As shown in the Figures, in one embodiment the electric motor (16) has a hollow rotor (20) into which the complementary shaped drive shaft (22) protrudes. Any suitable method of attaching the rotor (20) to the drive shaft (22) may be employed including, without limitation, a splined configuration or a bolted coupler.

As shown in Figure 13, in one embodiment the rotor (20) is hollow and the interior space is tapered. The hollow tapered rotor may be attached to the drive shaft (22) using a taper lock and key system. Keyed taper locks are commonly employed by those skilled in the art for attachment to a shaft. The drive shaft has a recess (36), or a keyway as it is known, for the insertion of a key (32). The key (32) is inserted into the keyway (36) and then the taper lock (34) slides onto the drive shaft (22) over the key (32) situated in the keyway (36) as shown in Figure 14. In one embodiment, the taper lock comprises a tapered bushing that has a split body with bolt holes (38) and which has complimentary recess or groove to accommodate the key (32) protruding out of the keyway (36). Next, as shown in Figure 15, the torque arm (18) and hollow tapered rotor (20) are placed over the taper lock (34) and then bolts (30) are passed through aligned bolt holes in the electric motor (16), the torque arm (18) and the taper lock (38). As the bolts are tightened, the electric motor (16) and torque arm (18) are pulled onto the taper lock (34) and there is a resultant force on the taper lock (34) which causes it to grip the drive shaft (22) with a positive clamping fit. The same attachment system may be employed with a crank shaft. If a hollow rotor is used, the hollow rotor should have a diameter wide enough to fit the largest commercially used drive shaft and may be narrowed to accommodate smaller drive shafts using sleeves or taper lock systems. Although the use of a keyed taper lock has been described, it should be understood that other suitable attachment systems may be used to attach a hollow rotor to a shaft including, without limitation, an interference fit, a slip fit or a bolted coupler.

It will be understood that with the rotor (20) directly attached to the drive shaft (22), rotation of the rotor (20) will cause corresponding simultaneous rotation of the drive shaft (22).

Accordingly, the apparatus (10) constitutes a direct drive system wherein the drive means of the fluid pump is directly driven without the need for intermediary gears, belts or chains. The direct drive system of the present invention has relatively fewer components, requires relatively lower levels of maintenance and has a relatively lower cost of production. It can be understood that if  
5 the drive means of the fluid pump comprises a crank shaft alone, the rotor may be attached to a crank shaft in the manner described above.

Although a hollow bore electric motor is particularly suitable, an electric motor having a solid shaft type rotor may also be used to practice the present invention. The solid rotor shaft may be coupled with the end of the drive shaft (22), or crank shaft as the case may be, by any suitable  
10 means such as bolted coupler. Additional support can be provided to support the weight of the electric motor if required. Such support may be provided by struts attached to the fluid pump, or by other suitable support mechanisms. In one embodiment, the torque arm (18) may be adapted such that it supports the weight of the electric motor (16).

More than one electric motor may be employed if higher levels of horsepower are required. For  
15 example, in one embodiment an electric motor may be mounted on both ends of the drive shaft (22). Generally, horsepower requirements of approximately 1600 horse power and higher require the use of more than one motor.

The motor (16) is optionally shrouded with guard plates (not shown in the Figures), which may be constructed from any suitable metallic material including twin plate steel.

20 The present invention is also directed to a method of powering the drive means of a fluid pump using an electric motor in a direct drive system. Employing the principles demonstrated in the apparatus (10), the method involves attaching the rotor of the electric motor to the drive shaft (22) or crank shaft of the fluid pump (12) and then and supplying electrical power to the electric motor (16) whilst restraining the electric motor to prevent rotation of the stator (21).

25 As will be apparent to those skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure can be made without departing from the scope of the invention claimed herein.

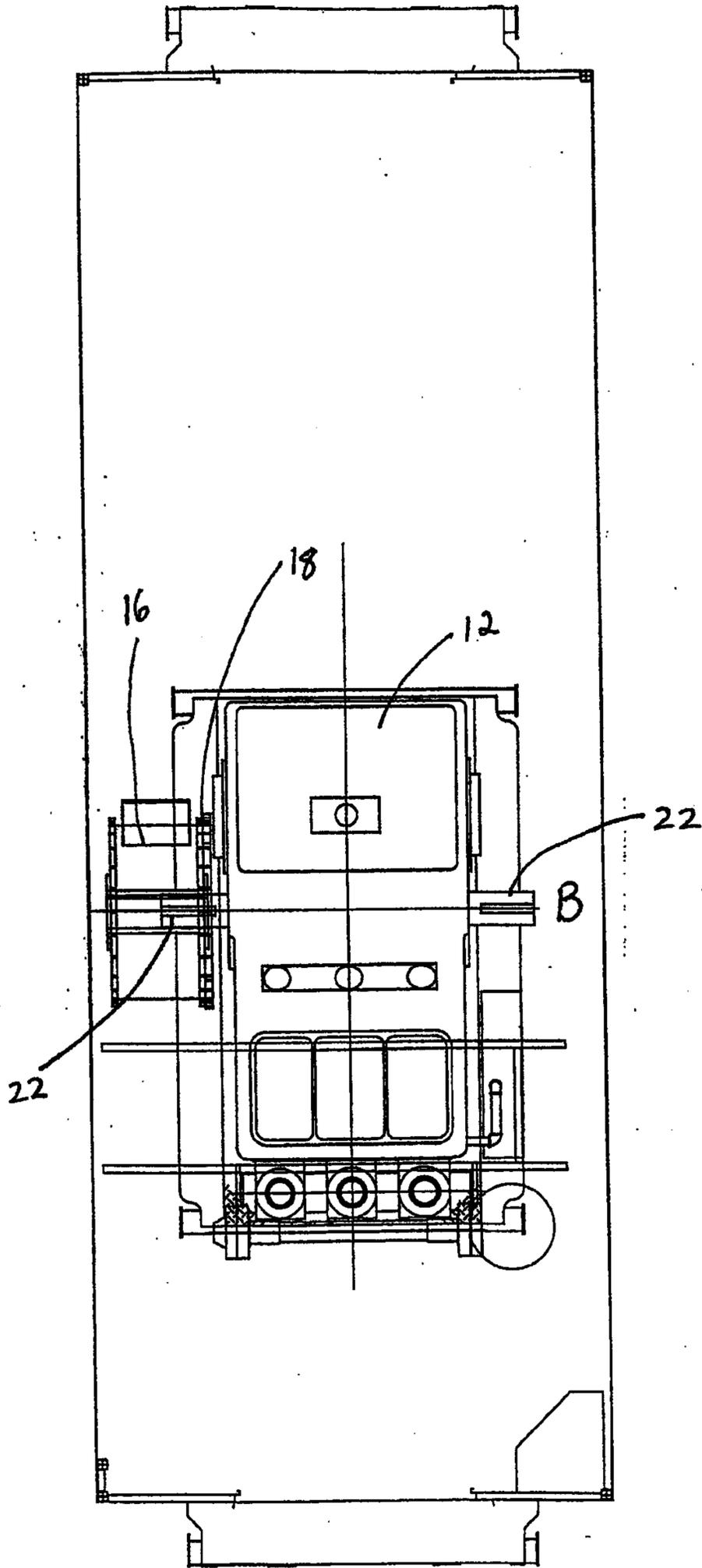
**WHAT IS CLAIMED IS:**

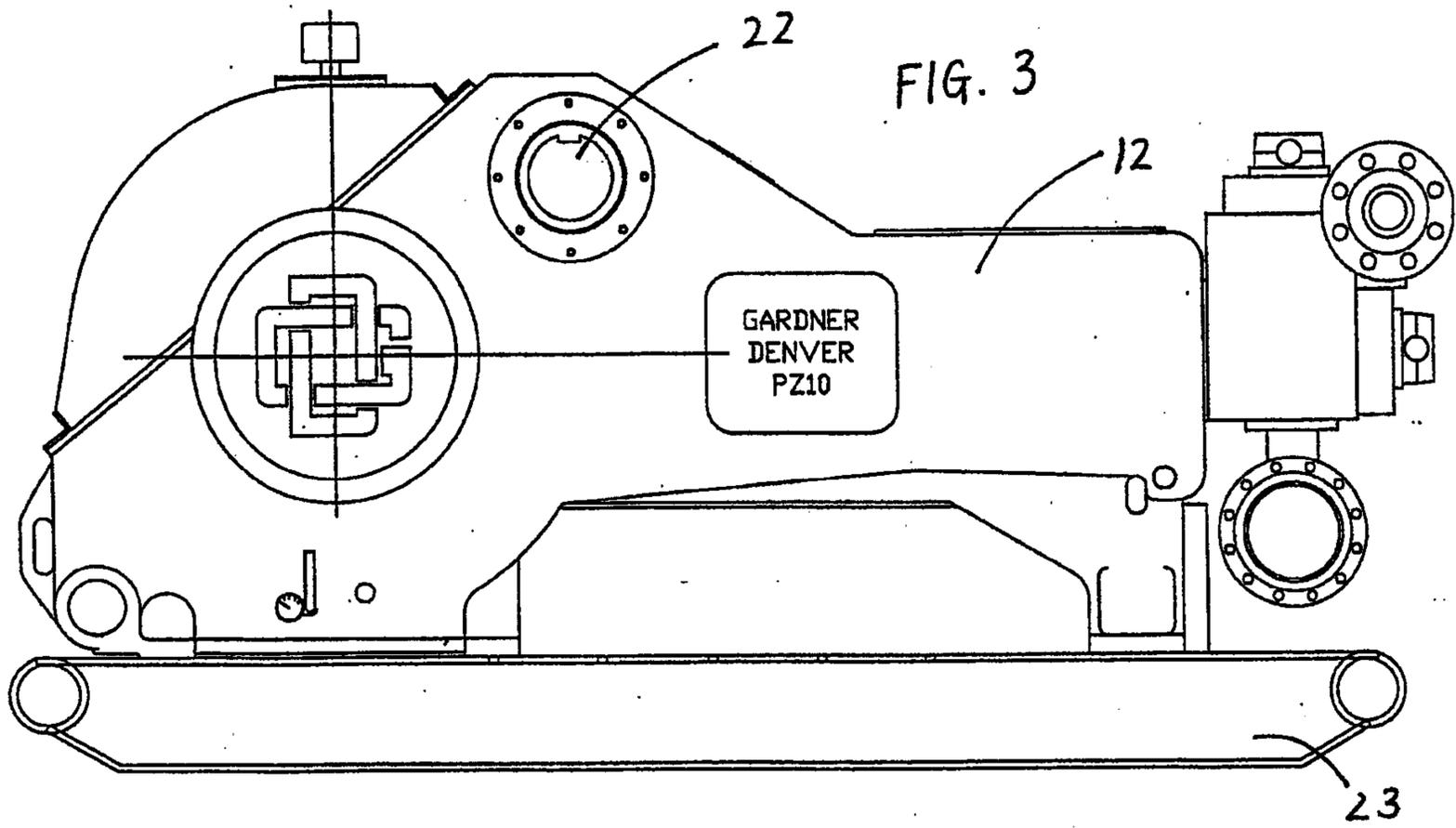
1. A drilling mud pump mounted on a base, said pump adapted to circulate drilling mud in a drilling operation and comprising:
  - 5 (a) a pump driveshaft or crankshaft;
  - (b) an electric motor directly connected to the pump driveshaft or crankshaft;
  - (c) a torque arm having a first end connected to the electric motor, and a second end restrained from rotational movement relative to the base; and
  - 10 (d) the drilling mud pump having an intake for receiving drilling mud from a storage facility and an outlet to deliver the drilling mud under pressure to a drill string.
2. The drilling mud pump of claim 1, wherein the electric motor has a stator and a hollow rotor.
- 15 3. The drilling mud pump of claim 2, wherein the hollow rotor slides onto and attaches to the pump driveshaft or crankshaft, such that the longitudinal axis of the hollow rotor and the longitudinal axis of the pump driveshaft or crankshaft are aligned.
4. The drilling mud pump of claim 2, wherein the interior of the hollow rotor is tapered, and  
20 the rotor is attached to the pump driveshaft or crankshaft using a taper lock.
5. The drilling mud pump of claim 2, wherein the torque arm is attached to the stator, the torque arm extending out and away from the electric motor in a plane that is substantially perpendicular to the longitudinal axis of the rotor.  
25
6. The drilling mud pump of claim 1, wherein the motor is an AC induction electric motor, or a DC traction electric motor, or a DC switch reluctant electric motor, or a permanent magnet electric motor.

7. A method of powering a driveshaft or crankshaft of a drilling mud pump mounted on a base, the drilling mud pump being configured to receive drilling mud from a storage facility and to deliver the drilling mud under pressure to a drill string, the method comprising the steps of:

- 5
- (a) directly connecting an electric motor to the pump driveshaft or crankshaft;
  - (b) supplying electrical power to the electric motor; and
  - (c) attaching a torque arm having a first end connected to the electric motor, and a second end restrained from rotational movement relative to the base.

FIG. 2





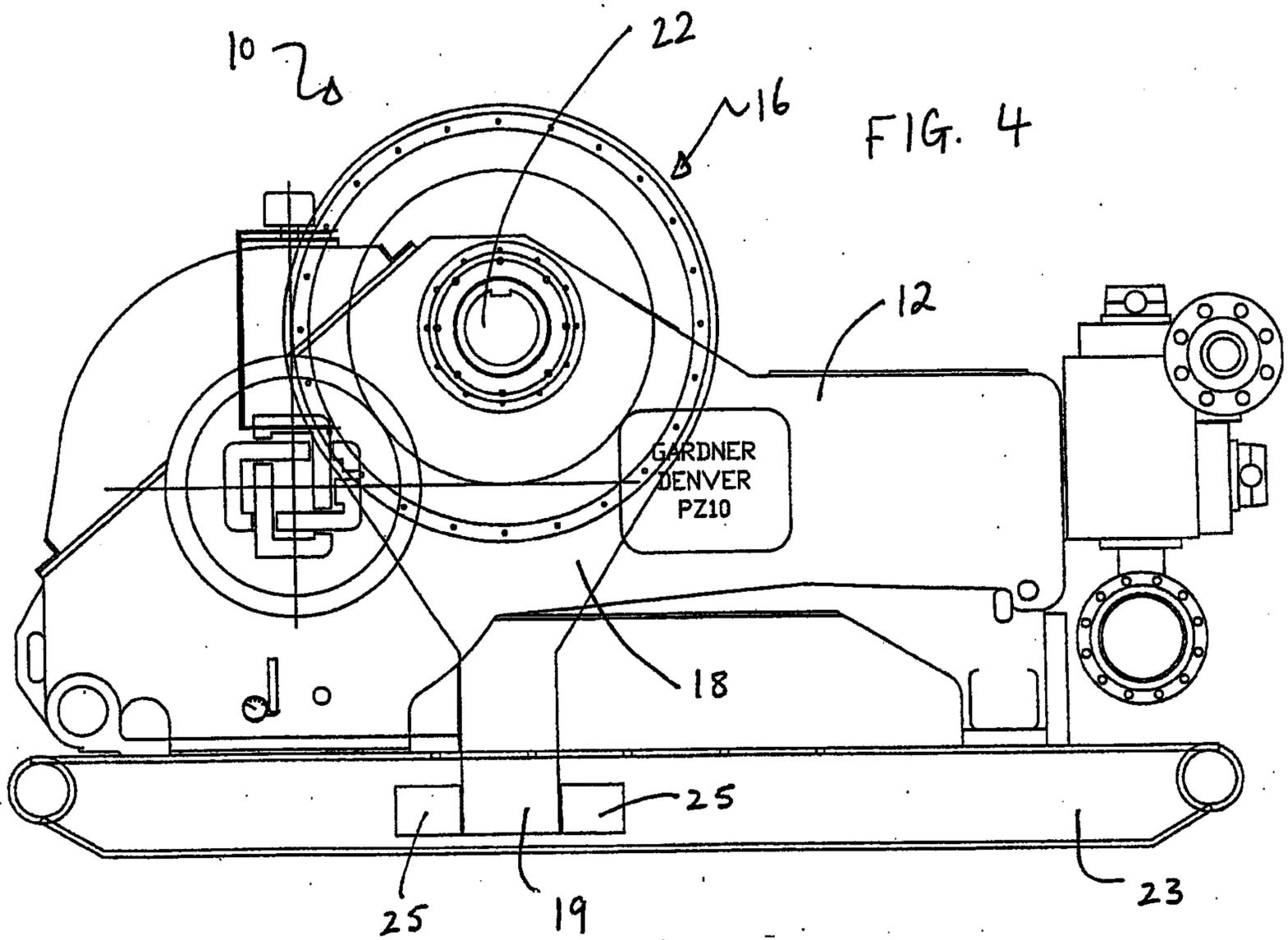


FIG. 5.

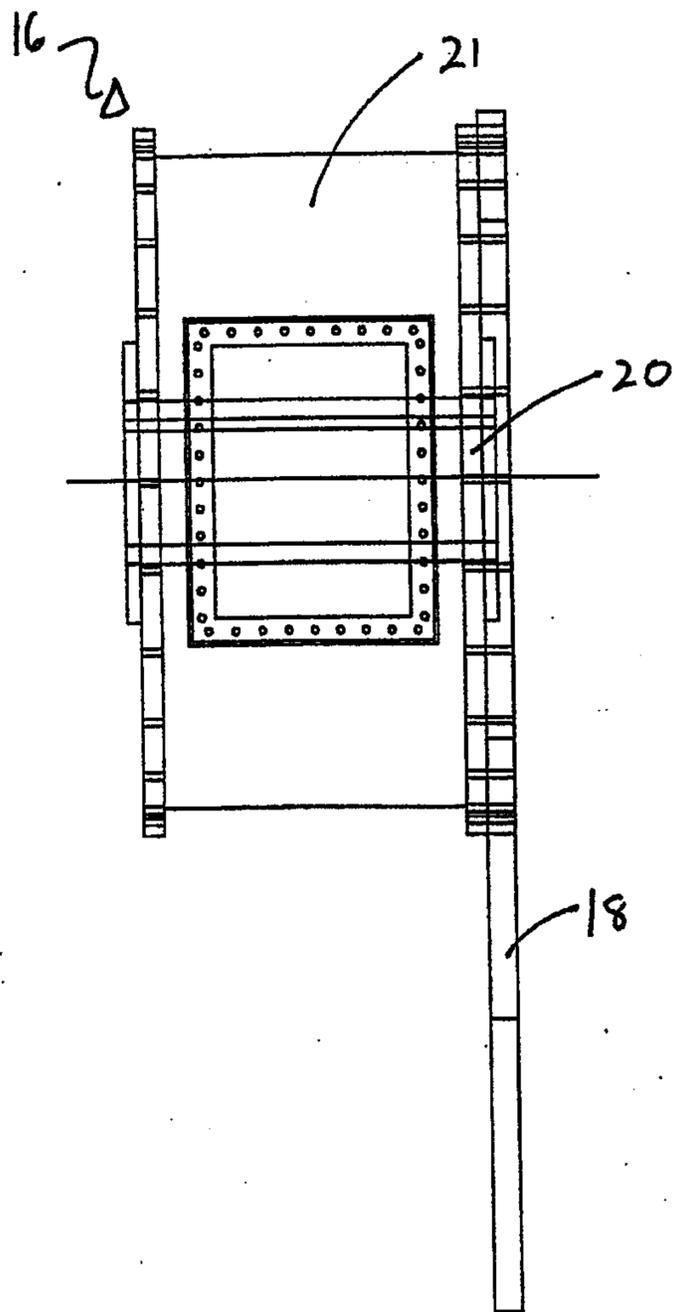


FIG. 6.

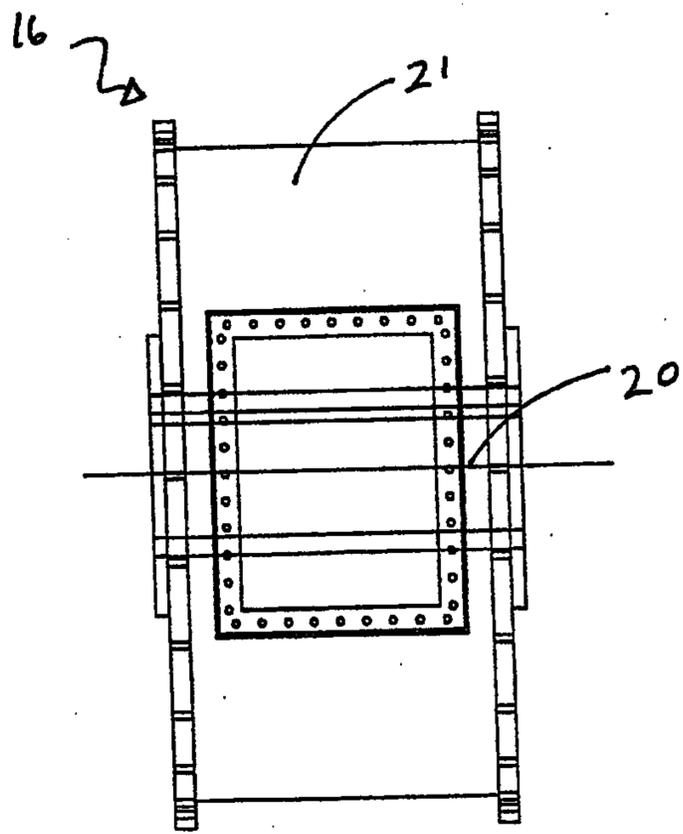


FIG. 7

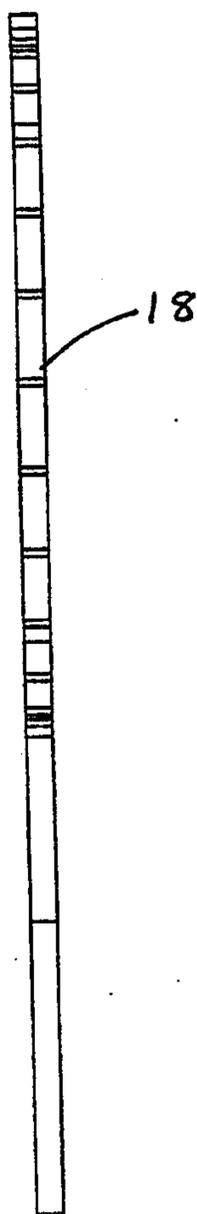
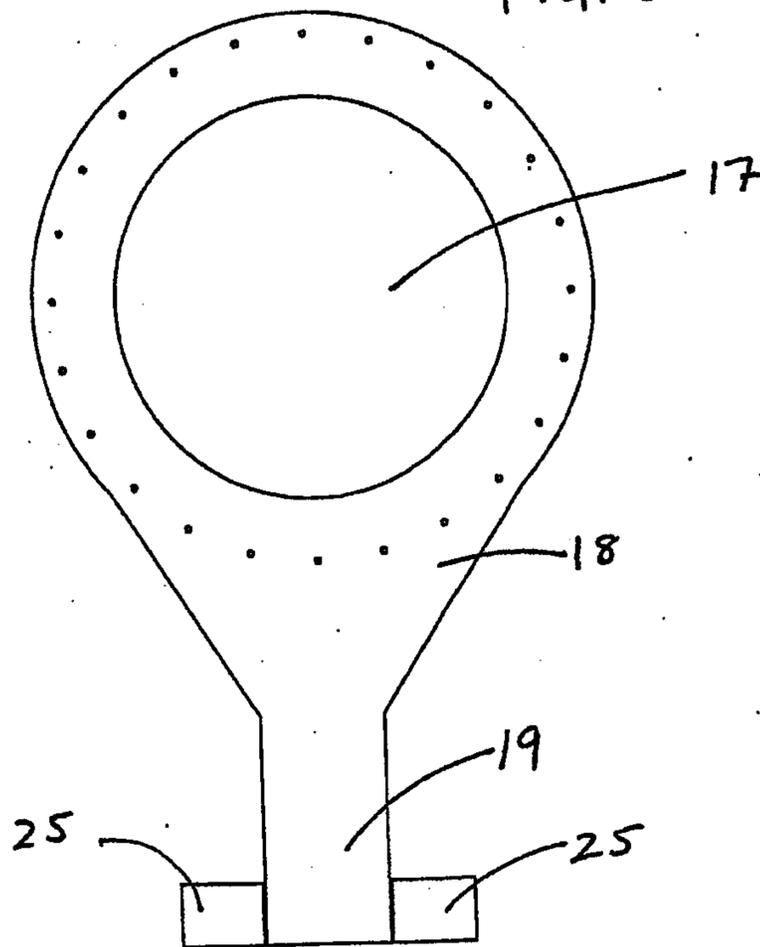
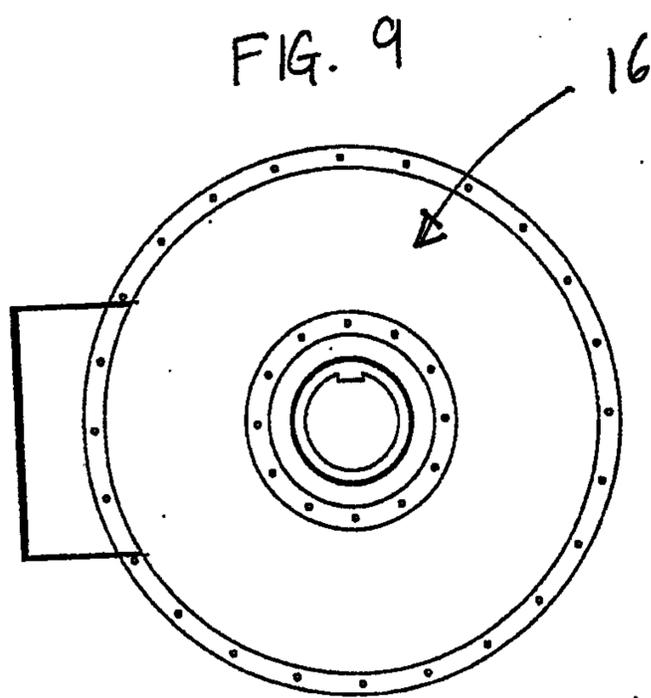


FIG. 8





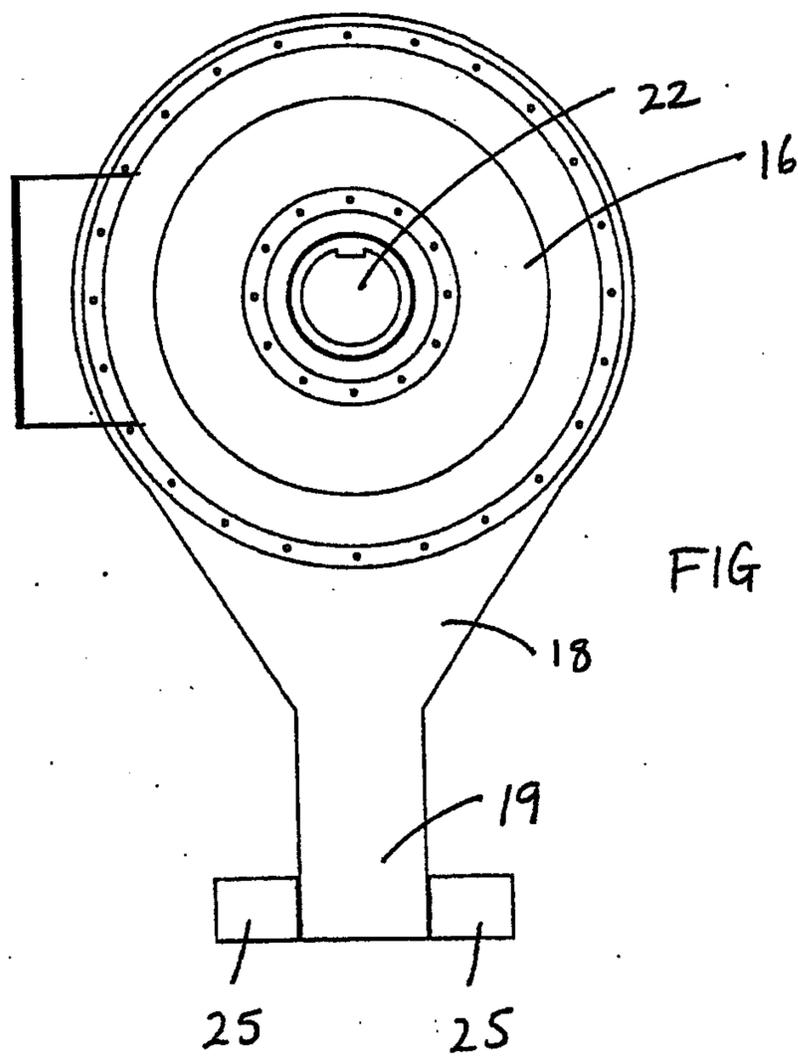


FIG 10

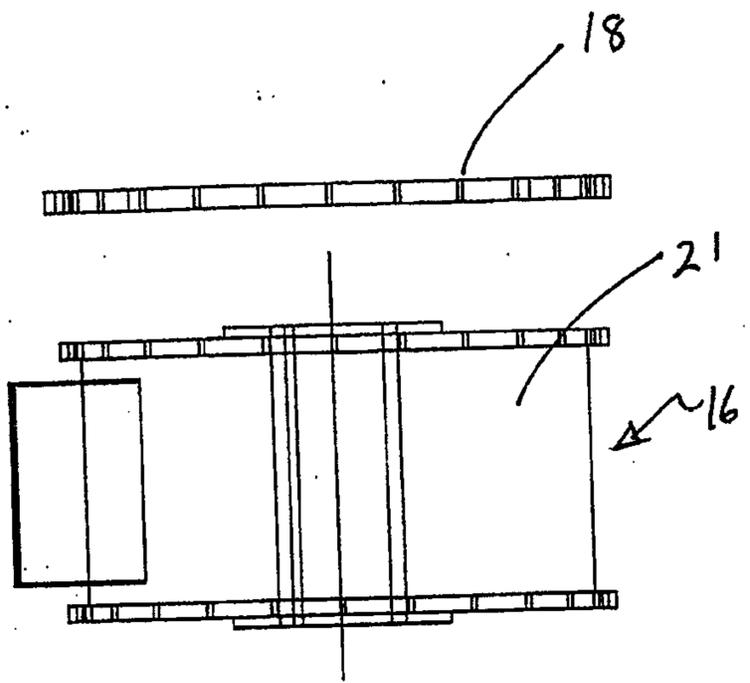


FIG 11.

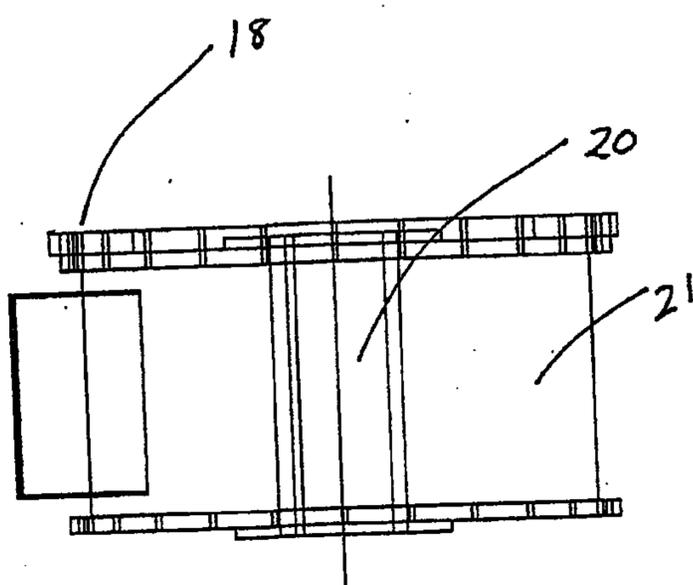


FIG 12.

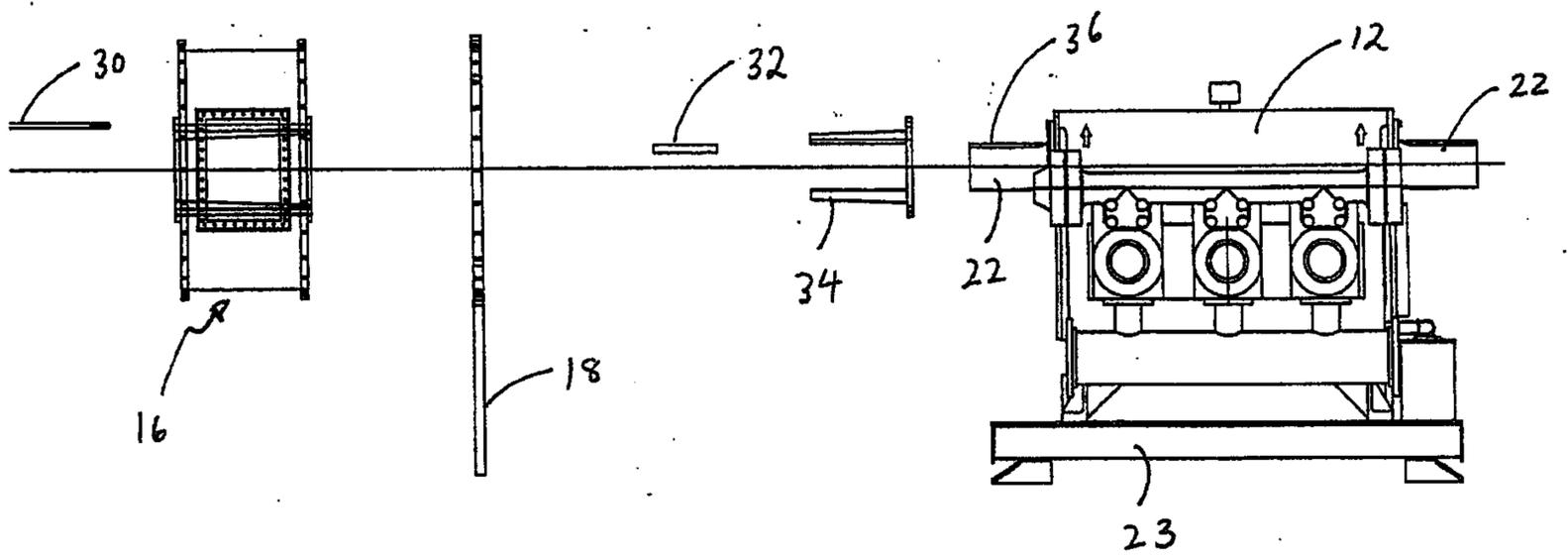


FIG 13.

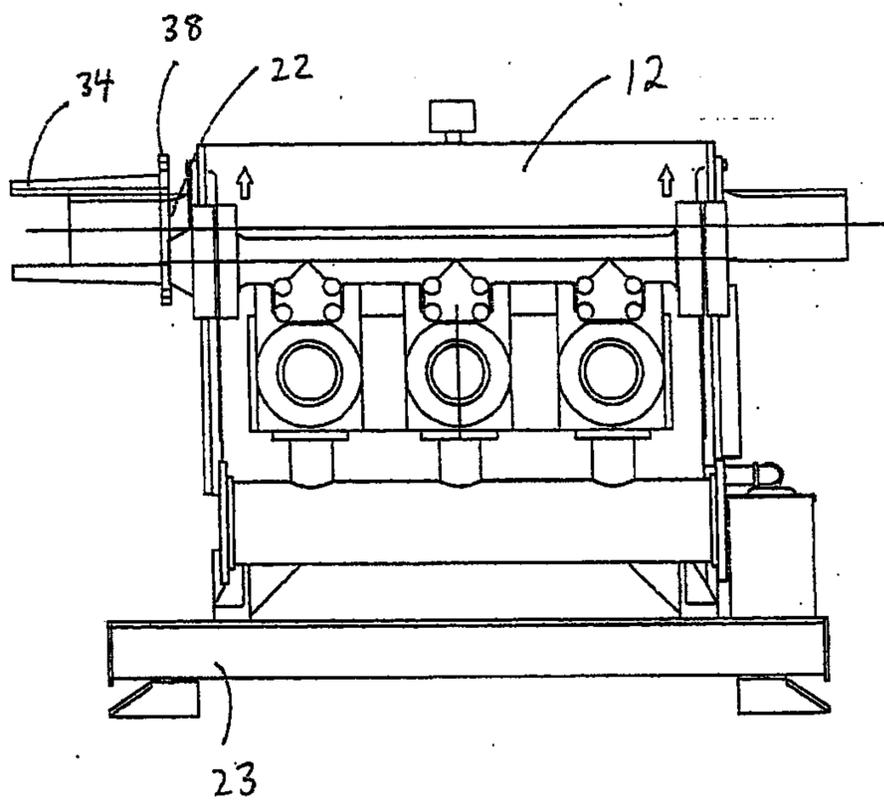
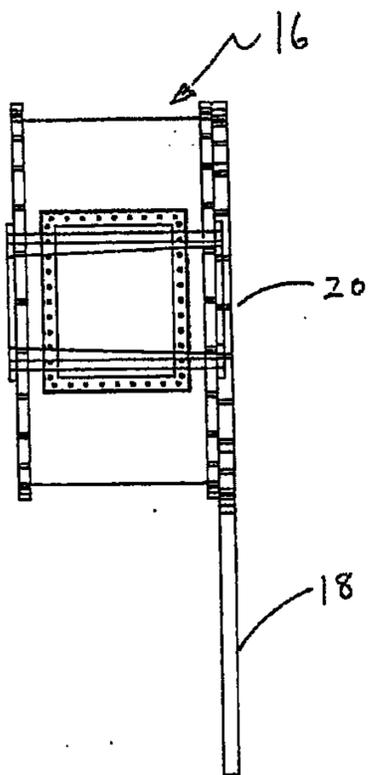
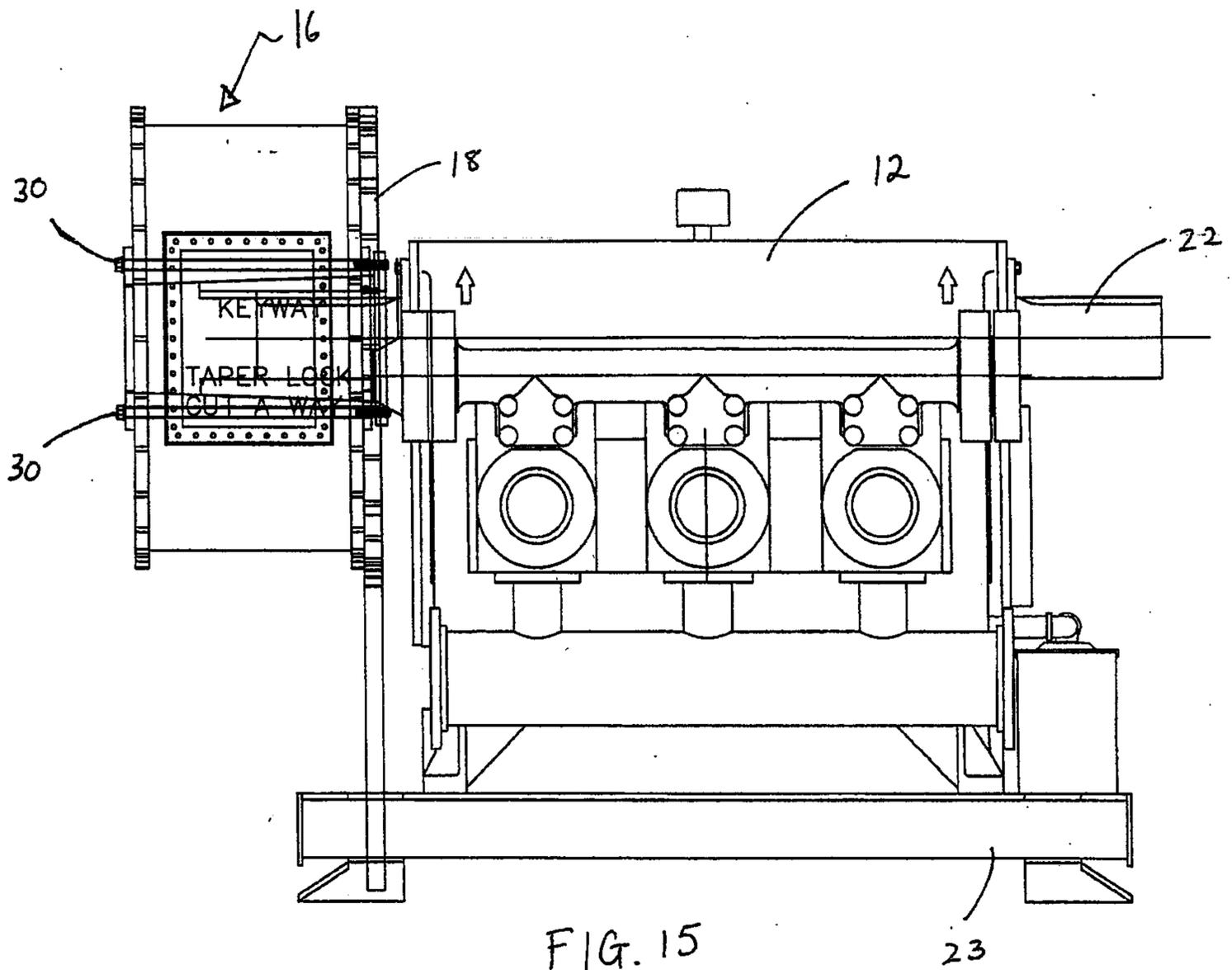


FIG 14.



Application number / numéro de demande: 2576182

Figures: 1

Pages: \_\_\_\_\_

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